Higher Capacitors Questions

1. a) Which **two** quantities are **capacitors** used to **store**?

b) State the **units** used to measure **capacitance**.

c) From the equation **Q = VC**, find an **alternative unit** for capacitance.

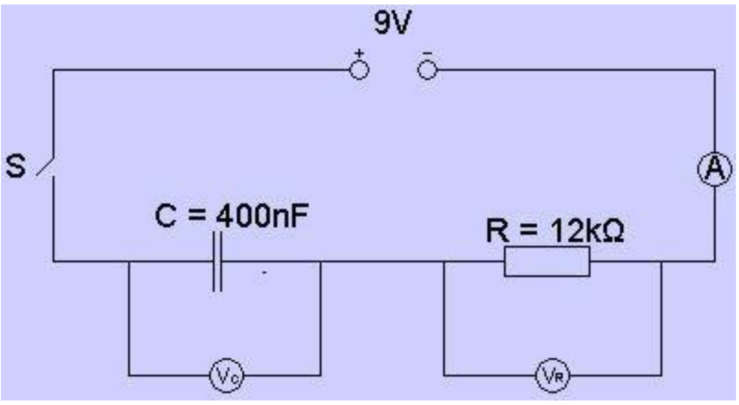
2. A **capacitor** is labelled **1800μF, 5V**.

Calculate or find:

a) **Charge stored** in the capacitor when it is **fully charged**.

b) **Energy stored** in the capacitor when it is **fully charged**.

3.



The **capacitor** is **initially uncharged**.

At the instant that the switch is closed, calculate or find:

a) Voltage across the capacitor.
b) Voltage across the resistor.
c) **Maximum** charging **current**.
d) Suitable **range** for the ammeter.

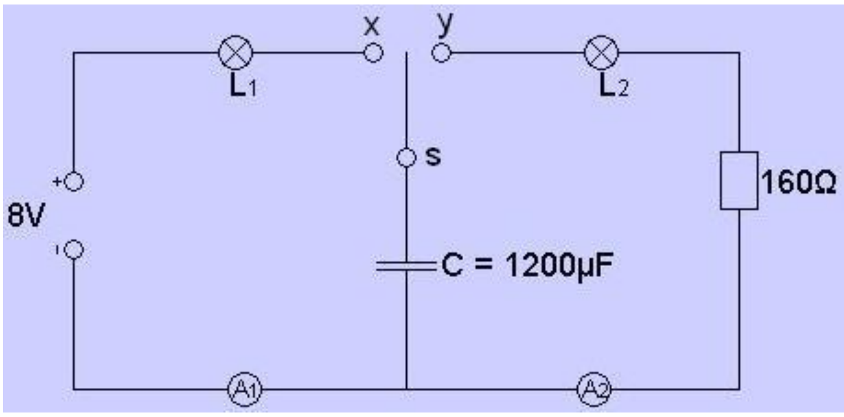
During the charging process:

e) **Reading** on the **ammeter** when the **voltage** across the **capacitor** is **6V**.

When the capacitor is fully charged, calculate or find:

f) Voltage across the capacitor.
g) Voltage across the resistor.
h) **Energy stored** in the capacitor.
i) **Charge stored** in the capacitor.

4.



In the circuit above, the capacitor **charges** up when the switch **connects S to X** and **discharges** when connected from **S to Y**.

The lamps L_1 and L_2 are considered as having negligible resistance.

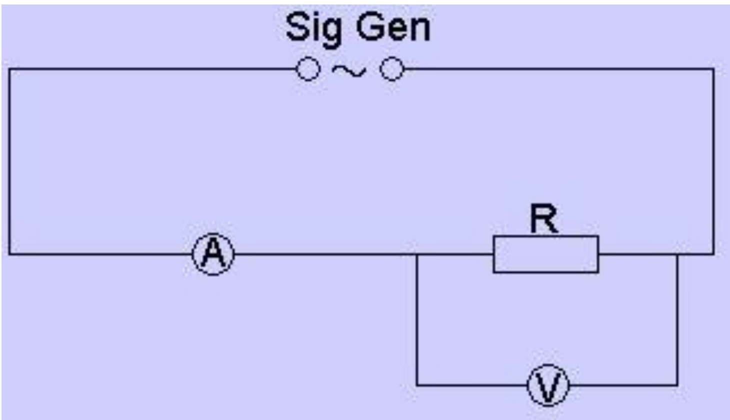
If the capacitor is fully charged and the switch changes from **SX to SY**, find:

a) **Initial current** during the discharge cycle.

b) **What is observed** during the discharge cycle:
i) On the **ammeter**.
ii) On the **brightness** of lamp $\mathbf{L_2}$.

c) If the **voltage** was increased from **8V to 10V**, how would this effect:
i) **Initial current** during the discharge cycle.
ii) Voltage across the **capacitor** when it is **fully charged**?

5.

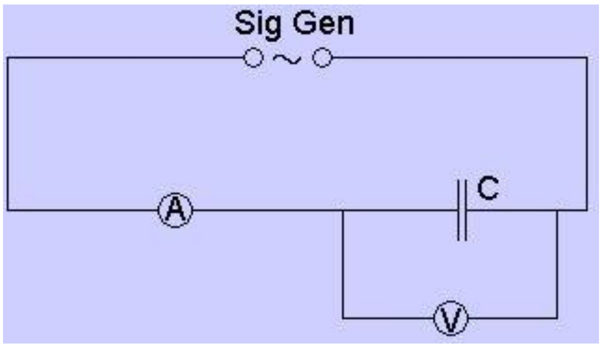


In the ac resistive circuit above, the relationship between **current and frequency** is investigated.

a) **What needs to be adjusted** after taking each set of readings of current and frequency?

b) What **relationship** is found between **current and frequency** and how is this shown from a **graph** drawn of these two quantities?

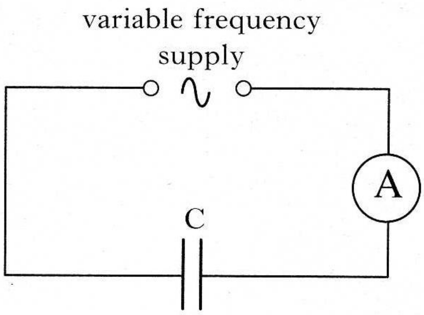
The resistor is replaced by a capacitor and the procedure is then repeated.



c) What **relationship** is found between **current and frequency** and how is this shown on a **graph** of these two quantities?

6.

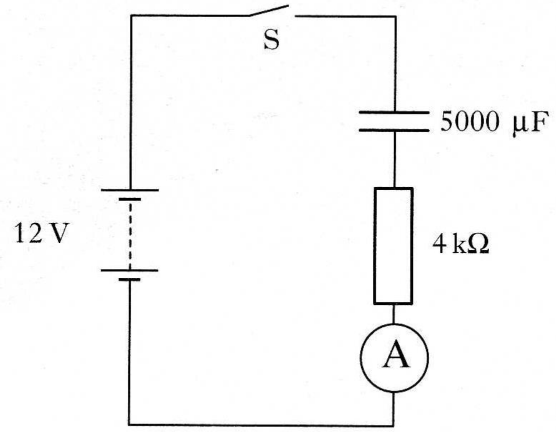
A capacitor is connected across a variable frequency supply as shown in the circuit below. The output of the supply has constant amplitude.



(*a*) (i) At a certain frequency, the current in the circuit is 200 mA r.m.s. Calculate the value of the peak current in the circuit.

(ii) The frequency of the output from the supply is now slowly increased. Sketch the graph of current against frequency for this circuit. Numerical values are not required but the axes should be clearly labelled.

(*b*) An uncharged capacitor and a resistor are connected across a 12 V d.c. supply with negligible internal resistance as shown below.

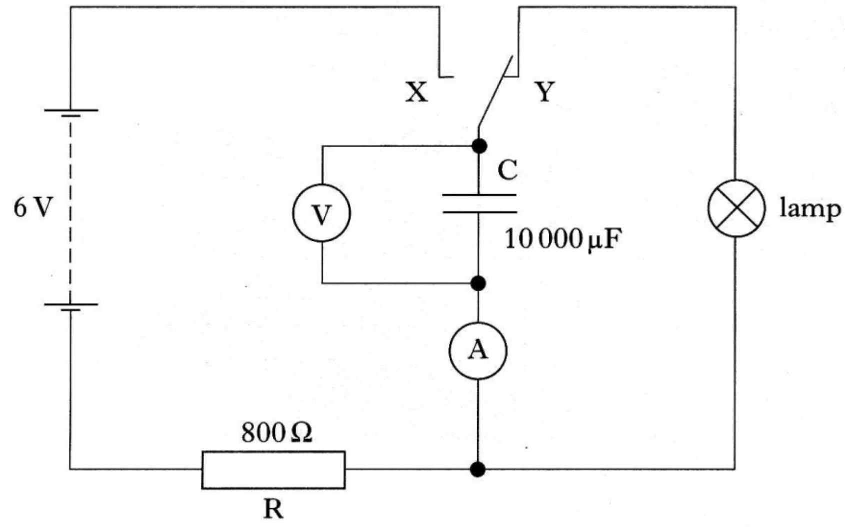


(i) The switch, S, is now closed and the capacitor charges. What charge is stored on the capacitor when the reading on the ammeter is 2 mA?

(ii) The capacitor is allowed to become fully charged. Calculate the energy now stored in the capacitor.

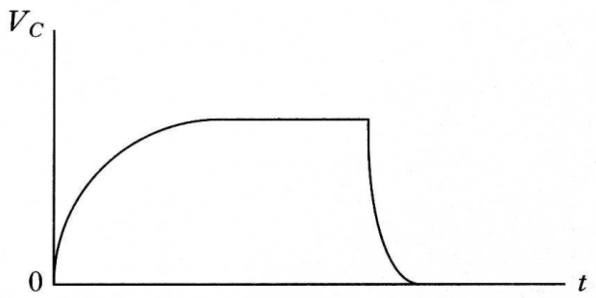
7.

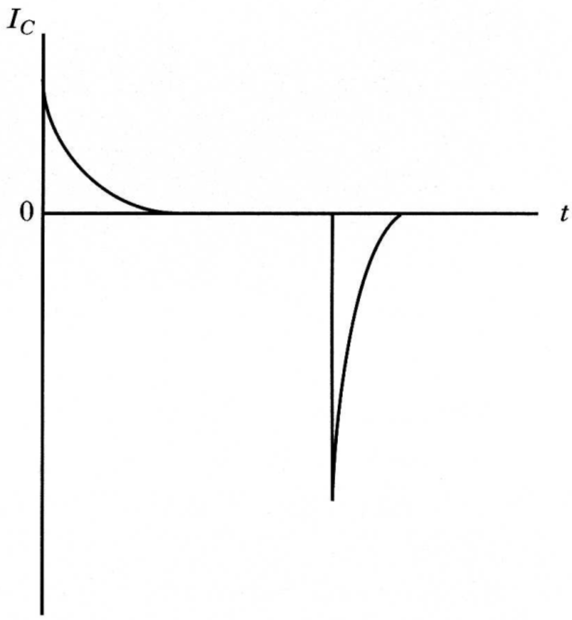
A student is investigating the charging and discharging of a 10 000 μF capacitor using the circuit shown below. The 6 V supply has negligible internal resistance.



Initially the capacitor is uncharged and the switch is in position Y. The switch is moved to position X until the capacitor is fully charged and then finally back to position Y.

The graphs below show the p.d. V_C across the capacitor and the current I_C in the ammeter during this process.





(*a*) (i) State the value of the p.d. across the capacitor when it is fully charged.

(ii) Calculate the maximum current during the charging process.

(iii) Sketch a graph showing how the p.d. across resistor R varies with time during the charging process. Numerical values are not required.

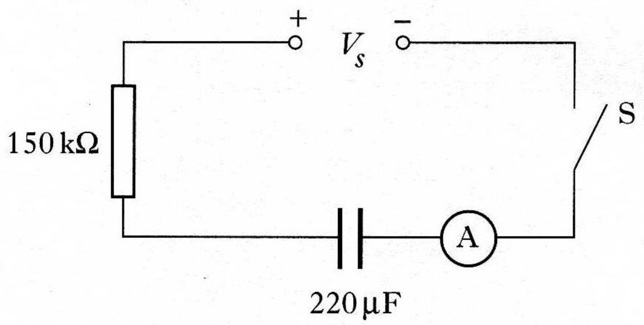
(*b*) The student deduces from the graph of current against time for the discharge that the resistance of the lamp is less than 800 Ω.

Explain why the student's deduction is correct.

(*c*) Calculate the energy stored in the capacitor when it is fully charged.

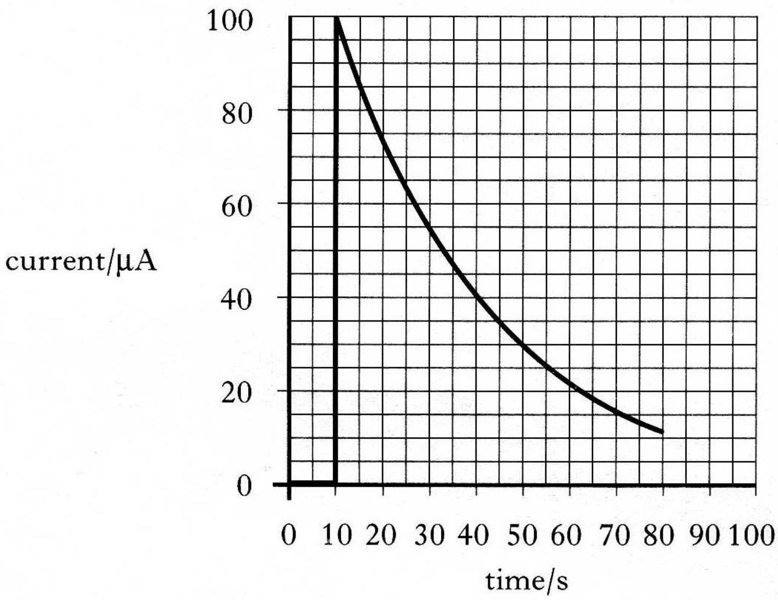
8.

(*a*) A capacitor of capacitance 220 μF is connected in series with a 150 kΩ resistor, a switch and an ammeter. A d.c. power supply of negligible internal resistance is connected to the circuit as shown below.



A stopclock is started and after 10 seconds the switch S is closed. Ammeter readings are noted at regular intervals until a time of 80 s is shown on the stopclock.

The graph below shows how the current in the circuit varies with time.



(i) Calculate the voltage V_s of the d.c. power supply.

(ii) At what time on the stopclock does the p.d. across the resistor equal 6 V?

(iii) What is the p.d. across the capacitor when the p.d. across the resistor is 6 V?

(*b*) A magazine article on the resuscitation of a heart attack victim describes the equipment used. This equipment uses a 16 μF capacitor which is charged until the p.d. across it is 6 kV. The capacitor is then fully discharged to give the heart a shock. The discharge time is 2 ms.

(i) When the capacitor is fully charged, calculate:

(A) the charge stored;

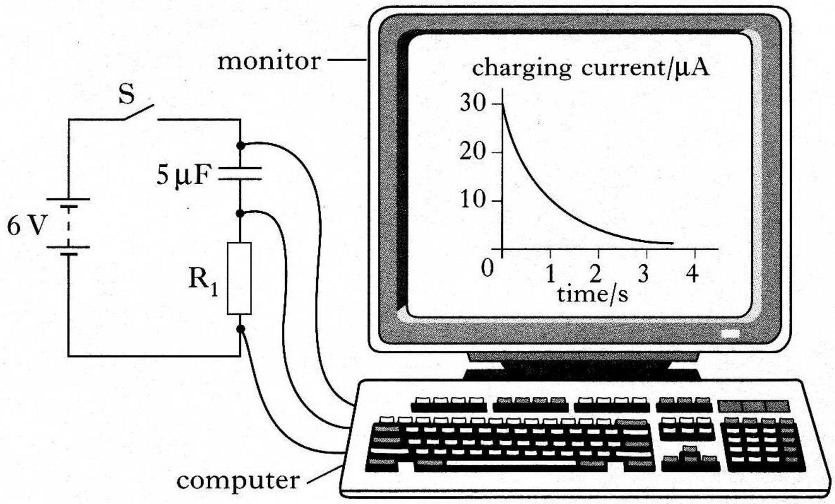
(B) the energy stored.

(ii) Calculate the average current during discharge.

9.

(*a*) A capacitor has a value of 5 μF. Explain in terms of electric charge what this means.

(*b*) The 5 μF capacitor shown in the circuit below is initially uncharged. The circuit is connected to a computer and switch S is closed. The monitor of the computer displays a graph of current against time as the capacitor charges.



The battery has negligible internal resistance.

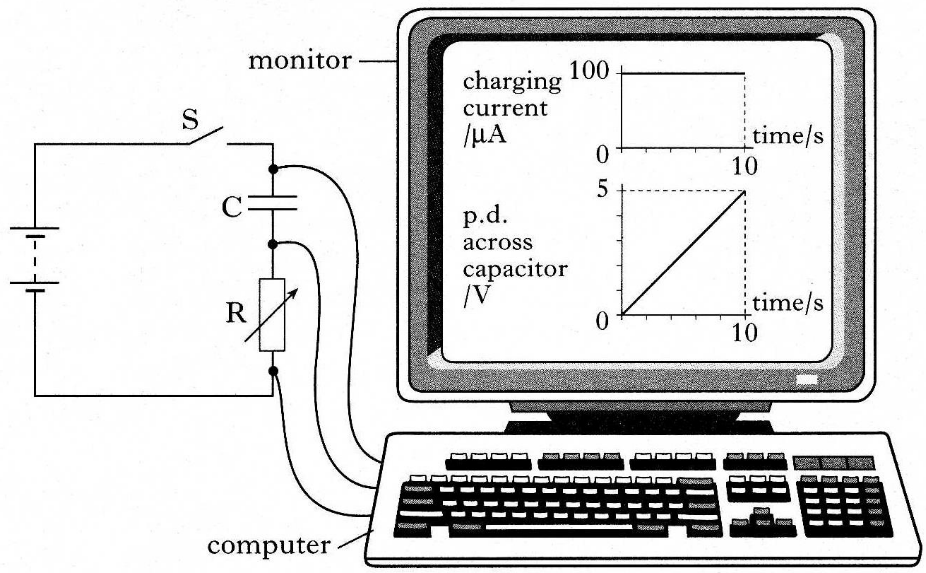
(i) Calculate the resistance of R_1.

(ii) The resistor R_1 is replaced by another resistor R_2. The resistance of R_2 is half that of R_1.

The capacitor is discharged and the experiment repeated.

Sketch the graph of charging current against time when R_2 is used. Include values on the axes.

(*c*) In the following circuit a variable resistor R is used to keep the current constant as a different capacitor charges. The graphs on the monitor show how the charging current and p.d. across the capacitor vary with time after switch S is closed.



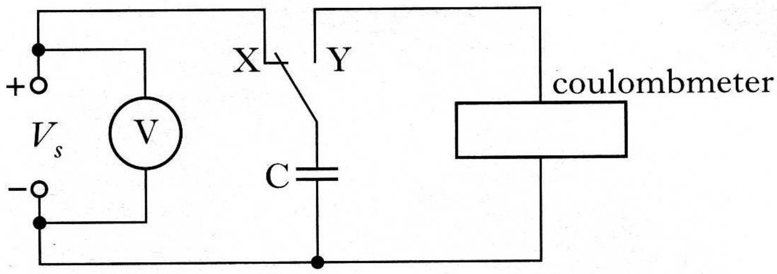
(i) What adjustment must be made to the variable resistor R so that a constant charging current is produced?

(ii) Show by calculation that 10 seconds after switch S is closed, the charge on the capacitor is 1mC.

(iii) Calculate the capacitance of C.

10.

(*a*) In an experiment to measure the capacitance of a capacitor, a student sets up the following circuit.



When the switch is in position X, the capacitor charges up to the supply voltage, V_s. When the switch is in position Y, the coulombmeter indicates the charge stored by the capacitor.

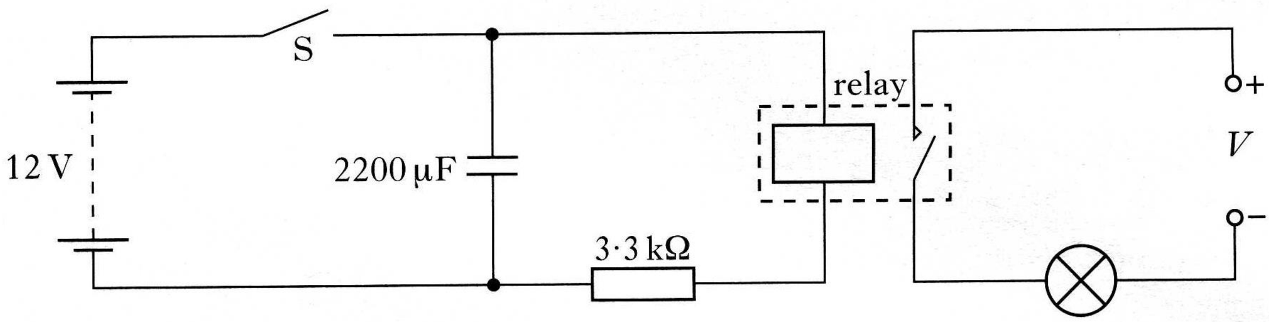
The student records the following measurements and uncertainties.

Reading on voltmeter = $(2 \cdot 56 \pm 0 \cdot 01)$ V
Reading on coulombmeter = (32 ± 1) μC

Calculate the value of the capacitance and the percentage uncertainty in this value. You must give the answer in the form

value ± percentage uncertainty.

(*b*) The student designs the circuit shown below to switch off a lamp after a certain time.



The 12 V battery has negligible internal resistance.

The relay contacts are normally open. When there is a current in the relay coil the contacts close and complete the lamp circuit.

Switch S is initially closed and the lamp is on.

(i) What is the maximum energy stored in the capacitor?

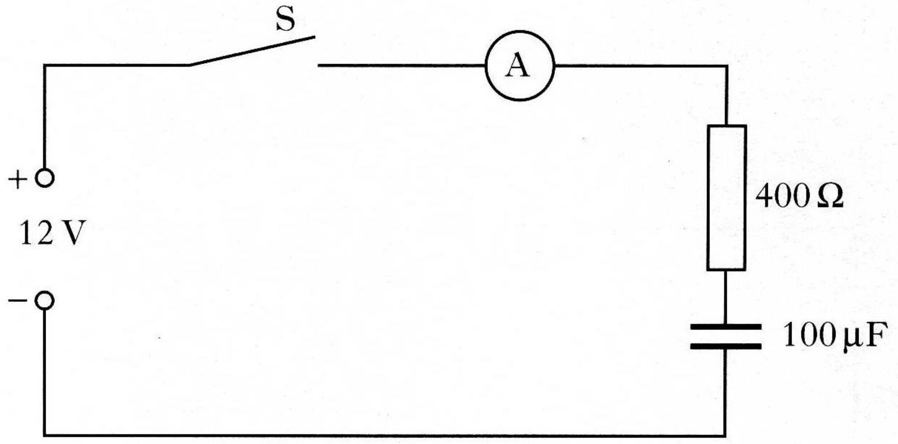
(ii) (A) Switch S is now opened. Explain why the lamp stays lit for a few seconds.

(B) The 2200 μF capacitor is replaced with a 1000 μF capacitor.

Describe and explain the effect of this change on the operation of the circuit.

11.

In an experiment, the circuit shown is used to investigate the charging of a capacitor.



The power supply has an e.m.f. of 12 V and negligible internal resistance. The capacitor is initially uncharged.

Switch S is closed and the current measured during charging. The graph of charging current against time is shown in figure 1.

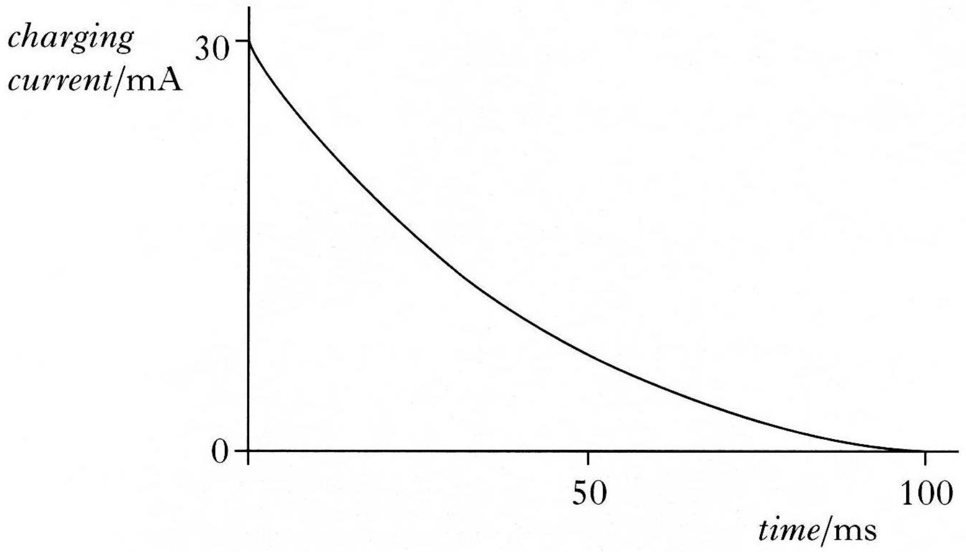


figure 1

(*a*) Sketch a graph of the voltage across the capacitor against time until the capacitor is fully charged. Numerical values are required on both axes.

(*b*) (i) Calculate the voltage across the capacitor when the charging current is 20 mA.

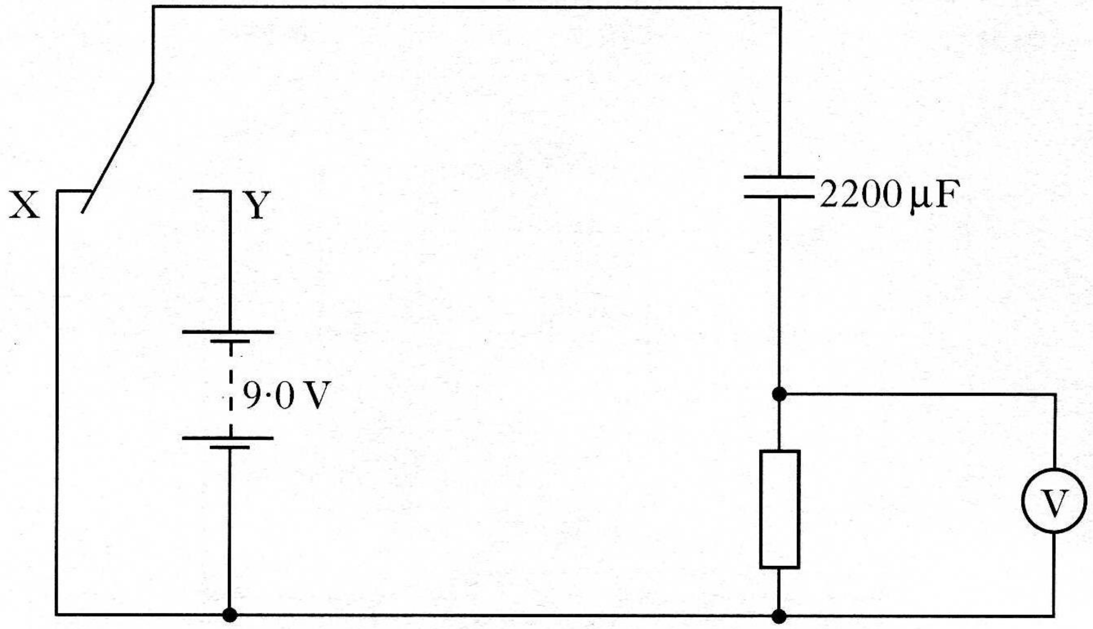
(ii) How much energy is stored in the capacitor when the charging current is 20 mA?

(*c*) The capacitor has a maximum working voltage of 12 V.

Suggest **one** change to this circuit which would allow an initial charging current of greater than 30 mA.

12.

A student investigates the charging and discharging of a 2200 μF capacitor using the circuit shown.



The 9·0 V battery has negligible internal resistance.

Initially the capacitor is uncharged and the switch is at position X.

The switch is then moved to position Y and the capacitor charges fully in 1·5 s.

(*a*) (i) Sketch a graph of the p.d. across the **resistor** against time while the capacitor charges. Appropriate numerical values are required on both axes.

(ii) The resistor is replaced with one of higher resistance.

Explain how this affects the time taken to fully charge the capacitor.

(iii) At one instant during the charging of the capacitor the reading on the voltmeter is 4·0 V.

Calculate the charge stored by the capacitor at this instant.

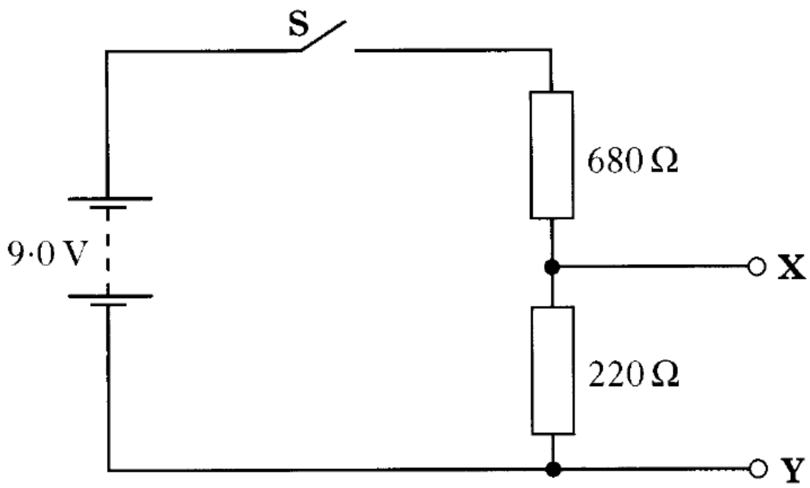
(*b*) Using the same circuit in a later investigation the resistor has a resistance of 100 kΩ. The switch is in **position Y** and the capacitor is fully charged.

(i) Calculate the maximum energy stored in the capacitor.

(ii) The switch is moved to position X. Calculate the maximum current in the resistor.

13.

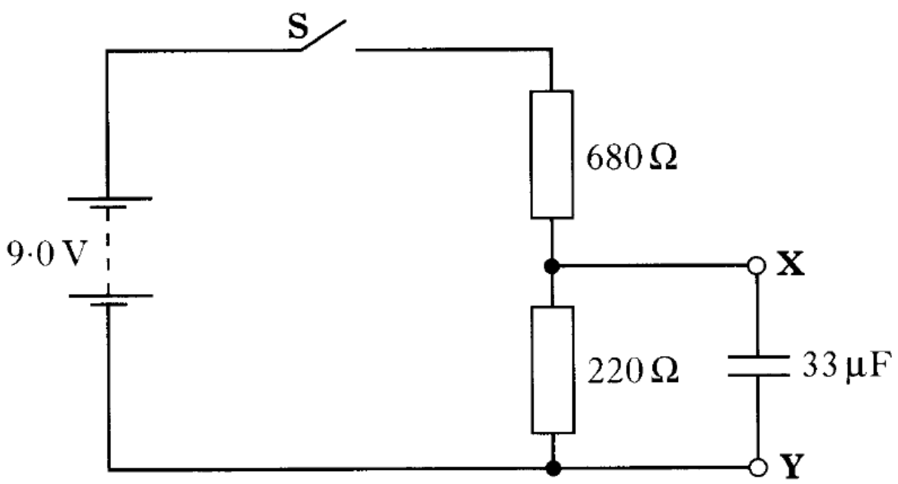
The 9·0 V battery in the circuit shown below has negligible internal resistance.



(*a*) Switch **S** is closed.
Calculate the potential difference between **X** and **Y**.

(*b*) Switch **S** is opened.

An uncharged 33 μF capacitor is connected between **X** and **Y** as shown.



Switch **S** is then closed.

(i) Explain why work is done in charging the capacitor.

(ii) State the value of the maximum potential difference across the capacitor in this circuit.

(iii) Calculate the maximum energy stored in the capacitor.

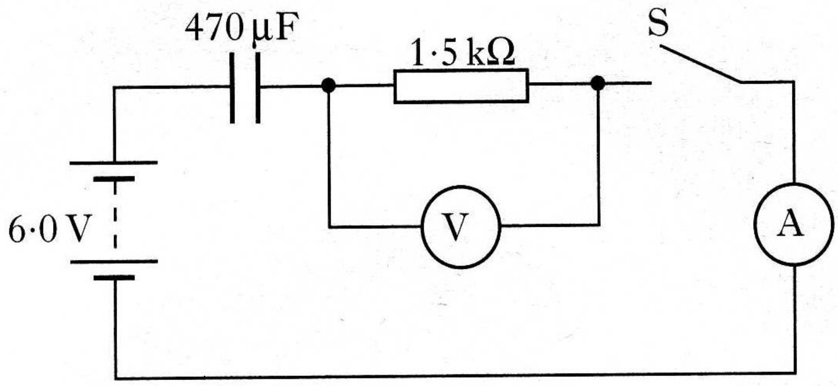
(iv) Switch **S** is now opened.

Sketch a graph to show how the current through the 220 Ω resistor varies with time from the moment the switch is opened.

Numerical values are required only on the current axis.

14.

(*a*) The following diagram shows a circuit that is used to investigate the charging of a capacitor.



The capacitor is initially uncharged.

The capacitor has a capacitance of 470 μF and the resistor has a resistance of 1·5 kΩ.

The battery has an e.m.f. of 6·0 V and negligible internal resistance.

(i) Switch S is now closed. What is the initial current in the circuit?

(ii) How much energy is stored in the capacitor when it is fully charged?

(iii) What change could be made to this circuit to ensure that the **same** capacitor stores **more** energy?

(*b*) A capacitor is used to provide the energy for an electronic flash in a camera.

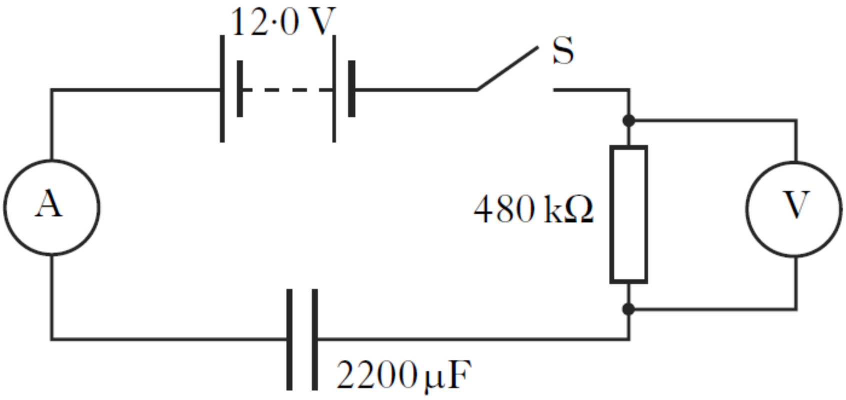
When the flash is fired, $6{\cdot}35 \times 10^{-3}$ J of the stored energy is emitted as light.

The mean value of the frequency of photons of light from the flash is $5{\cdot}80 \times 10^{14}$ Hz.

Calculate the number of photons emitted in each flash of light.

15.

An uncharged 2200 μF capacitor is connected in a circuit as shown.



The battery has negligible internal resistance.

(*a*) Switch S is closed. Calculate the initial charging current.

(*b*) At one instant during the charging process the potential difference **across the resistor** is 3·8 V.

Calculate the charge stored in the capacitor at this instant.

(*c*) Calculate the **maximum** energy the capacitor stores in this circuit.